



UNIVERSITI PUTRA MALAYSIA

**IMPROVING THE UTILIZATION OF OIL PALM FRONDS THROUGH
NITROGEN SUPPLEMENTATION IN DAIRY GOATS**

PRAMOTE PAENGKOUM

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By

PRAMOTE PAENGKOUM

**Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia,
in fulfillment of the Requirement for the Degree of Doctor of Philosophy**

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DEDICATION

I wish to dedicate this thesis to my beloved parents Nhupien and Pueng Paengkoum and respected teachers, supervisors who gave me the knowledge and experience and also wish to dedicate to all the tropical farmers.

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the Doctor of Philosophy

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Chairman: Associate Professor Liang Juan Boo, Ph.D.

Faculty: Agriculture

The high cost of supplementing poor quality roughage-based diets with imported protein concentrates for ruminants deserves attention in seeking cheaper alternatives. The purpose of the thesis was to determine the amount and type of nitrogen (N) sources, particularly the use of local protein foliages to enhance rumen ecology thus improving performance of dairy goats fed oil palm fronds (OPF).

Based on the above objectives, five experiments were conducted. Experiment 1 investigated the nutritional value and degradability of untreated oil palm fronds (U-OPF) and compared to steamed (S-OPF) and pre-pelleted and steamed OPF (PS-OPF). Dry matter (DM) and organic matter (OM) degradability of OPF subjected to steam treatment (S-OPF and PS-OPF) were higher ($P<0.05$) than the untreated OPF.

Experiment 2, investigated the optimum level of fermentable N (urea) supplementation to optimize the use of S-OPF by weaner goats. Five male Saanen goats of 4-6 months old and an average body weight (BW) of 21.4 ± 1.6 kg were used in a 5 x 5 Latin square experiment. The diet treatments were five levels of urea viz, 10, 20, 30, 40 and 50 g urea/kg of steamed OPF. Dry matter intake (DMI), nutrients digestibility, products of rumen fermentation, microbial N supply, N absorption and retention increased ($P<0.05$) with the addition of urea up to 30 g/kg OPF, and thereafter decreased ($P<0.05$) with increased urea supplementation. This implied that the optimal level of urea supplementation in a sole OPF diet was 30 g urea/kg steamed OPF.

The hypothesis that addition of fermentable energy will enhance the use of urea higher than 3% in OPF diet was validated in Experiment 3. Twelve Saanen goats aged between 5 to 6 months and BW of 23.4 ± 1.6 kg were used in a 2 x 3 Factorial arrangement of randomized complete block design. Factors were three levels of urea (3, 4 and 5%) and two levels of energy supplemented with cassava waste [low energy (LE) or high energy (HE)]. On the average, all production parameters measured were higher for HE as compared to LE diets. Nevertheless, the optimal level of urea supplementation remained at 3% in both diets.

Experiment 4 involved twelve Saanen goats of 3-4 months old with an initial BW of 18.8 ± 2.2 kg in a 4 x 4 Latin square experiment. The treatments were substitution of 4 levels of ruminally degradable protein (RDP) with soybean meal (SBM) for urea viz, 0, 20, 40 and 60% (Control, 20RDP, 40RDP and 60RDP, respectively). DMI,

microbial N supply and nutrient utilization increased linearly as a consequence of RDP substitution with SBM. There were progressive improvements of BW gain of goats from 25 g/d fed 10 g urea/kg OPF to 49 g/d when the OPF diet was supplemented with 30 g urea/kg OPF (Experiment 2). The BW gain increased to 86 g/d when the diet was supplemented with energy (Experiment 3), and further increased to 130 g/d when RDP from urea were substituted by SBM (Experiment 4).

Experiment 5 consisted of two trials. In the first, DM and CP degradability of three types of protein foliages, viz cassava, leucaena and kenaf foliages were compared to SBM. The DM and CP degradability of SBM, kenaf, cassava were higher ($P<0.05$) than that of leucaena foliages. In the second trial, twelve lactating dairy goats were used in a 3 (diets) x 3 (periods) Latin square experiment. Dietary treatments consisted of SBM as protein source (Control) and 50% of SBM protein was substituted with either cassava or kenaf foliages. Nutrient intakes, ruminal characteristics, microbial N supply, milk yield and milk compositions were not significantly different among diets.

It is concluded that steam treatment improved the nutritive value of OPF. Supplementation of 30 g urea/kg OPF and fermentable energy in OPF diet enhanced rumen ecology and thus animal performance. In addition, protein foliages such as cassava and kenaf foliages could substitute up to 50% protein of SBM without reducing the performance of lactating goats.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi syarat keperluan untuk Ijazah Doktor Falsafah

**PENINGKATAN PENGGUNAAN DAUN KELAPA SAWIT MELALUI
SUPLEMENTASI NITROGEN PADA KAMBING TENUSU**

Oleh

PRAMOTE PAENGKOUM

April 2003

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Kos yang tinggi didalam penambahan diet berasaskan serat berkualiti rendah dengan konsentrat protein yang diimport untuk ruminan perlu perhatian didalam mencari alternatif yang murah. Tesis ini bertujuan untuk menentukan amaun dan jenis sumber nitrogen (N), terutama penggunaan foliag protein tempatan untuk memperkayakan ekologi rumen seterusnya meningkatkan prestasi kambing tenusu yang memakan daun kelapa sawit (OPF).

Berdasarkan objektif diatas, lima eksperimen telah dijalankan. Eksperimen 1 menyiasat nilai permakanan dan degradasi daun kelapa sawit yang tidak dirawat (U-OPF) dan dibanding dengan daun yang dirawat dengan wap (S-OPF) dan pra-pelet serta diwapkan (PS-OPF). Degredasi bahan kering (DM) dan bahan organik (OM) bagi subjek OPF yang ditujukan rawatan wap (S-OPF dan PS-OPF) adalah lebih tinggi ($P<0.05$) berbanding kumpulan OPF yang tidak dirawat.

Eksperimen 2 menyiasat paras optimum suplementasi N mudah difermentasikan (urea) untuk mengoptimumkan penggunaan S-OPF oleh kambing muda. Lima kambing jantan Saanen yang berumur 4-6 bulan dengan purata berat badan (BW) 21.4 ± 1.6 kg telah digunakan di dalam satu eksperimen 5 x 5 segi empat Latin. Rawatan adalah lima paras urea; 10, 20, 30, 40 dan 50 g urea/kg S-OPF. Pengambilan bahan kering (DMI), pencernaan nutrien, produk fermentasi rumen, pembekalan N mikrob dan penyerapan dan pembendungan N meningkat ($P < 0.05$) dengan peningkatan urea hingga 30 g/kg OPF, dan seterusnya menurun ($P < 0.05$) dengan penambahan suplementasi urea. Ini membayangkan bahawa paras optimum suplementasi urea di dalam diet OPF sahaja adalah 30 g urea/kg OPF.

Perakuan hipotesis bahawa dengan penambahan tenaga terfermentasi akan meningkatkan penggunaan urea lebih tinggi dari 3% di dalam diet OPF dilakukan dalam Eksperimen 3. Dua belas kambing baka Saanen berumur 5-6 bulan dengan purata berat badan 23.4 ± 1.6 kg telah digunakan didalam susunan Faktorial 2 x 3 dalam rekabentuk blok lengkap rawak. Faktornya ialah 3 paras urea (3, 4 dan 5%) dan dua paras tenaga dengan suplemen hasil buangan ubi [tenaga rendah (LE) atau tenaga tinggi (HE)]. Secara purata, semua parameter yang diukur adalah lebih tinggi untuk diet HE berbanding diet LE. Walaubagaimanapun, tahap optimum suplementasi urea kekal pada paras 3% untuk kedua-dua diet.

Eksperimen 4 melibatkan 12 kambing baka Saanen berumur 3-4 bulan dengan berat badan 18.8 ± 2.2 kg didalam eksperimen 4 x 4 segi empat Latin. Rawatan ialah penggantian 4 paras protein terdegradasi rumen (RDP) dengan kacang soya (SBM)

untuk urea; 0, 20, 40 dan 60% (Kawalan, 20RDP, 40RDP dan 60RDP, masing-masing). DMI, pembekalan N mikroba dan penggunaan nutrien meningkat secara linear akibat penggantian RDP dengan SBM. Terdapat peningkatan progresif ke atas penambahan berat badan kambing dari nilai negatif pada kambing yang dibekalkan OPF sahaja meningkat kepada 49 g/hari apabila diet OPF ditambah dengan 30 g urea/kg OPF (Eksperimen 2), dan 86 g/hari apabila diet terus ditambah dengan tenaga (Eksperimen 3) dan meningkat kepada 130 g/d apabila RDP dari urea digantikan dengan SBM (Eksperimen 4).

Eksperimen 5 mengandungi dua percubaan. Dalam percubaan pertama, degradasi bahan kering (DM) dan CP bagi tiga jenis foliag protein; ubi kayu, leucaena dan kenaf dibandingkan dengan SBM. Degradasi DM dan CP SBM, kenaf dan ubi kayu adalah lebih tinggi daripada foliag leucaena. Di dalam percubaan kedua, 12 kambing yang sedang laktasi telah digunakan di dalam eksperimen 3 (diet) x 3 (jangkamas) segi empat Latin. Rawatan diet adalah SBM sebagai sumber protein (Kawalan) dan 50% protein SBM digantikan dengan ubi kayu atau foliag kenaf. Tidak terdapat perbezaan signifikan pengambilan nutrien, percirian ruminan, bekalan N mikroba, penghasilan dan komposisi susu terhadap perbezaan diet.

Kesudahannya ialah rawatan wap meningkatkan nilai nutrisi OPF. Suplementasi 30 g urea/kg OPF dan tenaga terfermentasi di dalam diet OPF dapat memperkayakan ekologi rumen dan prestasi haiwan. Sebagai tambahan, foliag protein seperti ubi kayu dan foliag kenaf dapat menggantikan 50% protein dari SBM tanpa menurunkan prestasi kambing dalam laktasi.

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I certify that an Examination Committee met on 10th April 2003 to conduct the final examination of Pramote Paengkoum on his Doctor of Philosophy thesis entitled "Improving the Utilization of Oil Palm Fronds through Nitrogen Supplementation in Dairy Goats" in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Regulations 1981. The Committee recommends that the candidate be awarded the relevant degree. Members of the Examination Committee are as follows:

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DECLARATION

I hereby declare that the thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at UPM or other institutions.


PRAMOTE PAENGKOUM

Date : 25 April 2003

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ABBREVIATIONS

ADF	acid detergent fiber
ADG	average daily gain
ADL	acid detergent lignin
AOAC	Association of Official Analytical Chemists
ARC	Agriculture Research Council
BW	body weight
CP	crude protein
D	day
DM	dry matter
DMI	dry matter intake
EE	ether extract
FAO	Food and Agriculture Organization
g	gram
GC	gas chromatography
GE	gross energy
GLM	General Linear Model
h	hour
HP	heat production
HPLC	high pressure liquid chromatography
kcal	kilo calorie
kJ	kilo Joules
L	litres

MARDI	Malaysian Agricultural Research and Development Institute
ME	metabolize energy
MEI	metabolize energy intake
mg	milligram
mmol	millimole
N	nitrogen
NDF	neutral detergent fiber
NH₃-N	ammonia nitrogen
NRC	National Research Council
OM	organic matter
OMDR	organic matter digested in the rumen
OPF	oil pal fronds
P	phosphorus
PD	purine derivatives
PUN	plasma urea nitrogen
RDP	ruminal digestible protein
RM	Ringgit Malaysia
SAS	Statistical Analysis System
SEM	standard error of mean
VFA	volatile fatty acid
W^{0.75}	metabolic weight

CHAPTER 1

INTRODUCTION

Demand of animal protein increased with increasing population and standard of living. The increased demand for animal protein can only be satisfied by intensification of livestock production (Leng, 1993; FAO, 2002). Meat and milk production from goats is one solution to meet the increasing demand. Goat's milk is recognised as a valuable source of dietary protein for small-holder farm families to improve their nutritional status and health (Devendra, 1991; Wanapat and Devendra, 1999). Moreover, dairy goats are easy to handle and are well suited to village scale and/or industrial production systems. However, availability of good local feed resources is often a constraint for efficient production of these animals (Dynes *et al.*, 2002; Wanapat, 2002).

In order to develop appropriate feeding systems, information on the nutritional characteristics of feed resources to meet the animal requirements based on their production phases must be known. Fibrous feeds contain large amount of complex carbohydrates which are not digestible by intestinal enzymes of the host animals and therefore require prior fermentative digestion by microbes. The common characteristics of such feed are low digestibility, low mineral and nitrogen (N) contents which further limit dietary intake (Leng, 1991; Dryhurst and Wood, 1998). The goal of nutritional management of feeding high producing animals should be to optimize ruminal fermentation so that microbial growth is maximized. Microbial